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SCIENCE

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THE AIM AND FUTURE OF NATURAL SCIENCE.¹

THE aim of science is twofold: we study science that we may know the truth, and that we may utilize that truth for the material and moral advantage of humanity. Of these two aims, the higher and less common is the former. Many persons will naturally inquire what advantage there can be in seeking truth for its own sake only; yet nearly all the practical applications of discovered truths have been based upon principles which have been attained, not by the so-called practical men, but by those whose lives were devoted to what has been opprobriously called the "mere getting of knowledge." It was with perhaps no slight tinge of sarcasm that Pilate exclaimed, when brought face to face with Jesus of Nazareth, "What is truth?" Nevertheless, to this question man has, from his earliest appearance upon this planet, sought for a reply; and, so long as man shall exist as man, he will never abandon his search. One form of this search is curiosity, and we call it idle; but it is far from idle in its origin. It is the insatiable desire, inborn in every man, to find out that which he does not know. It is this which led a Galileo to the torture, and a Bruno to the stake; it is this that has caused men to forsake family and friends, devoting their wealth and health, and all that the world calls happiness, to seeking truth. The little child at its mother's knee begins to imagine the why of the phenomena surrounding it; and the old man sinks into his grave, still pondering on the unsolved problems of life which he must abandon, hoping that in another world he may find the key to the mysterious hieroglyphics he leaves behind. Perhaps the origin of this desire rests on the fact that in nature itself, formed by the Almighty, we find the marks of His fingers. By studying science we are but studying His methods of working in the natural world; and thus we are like Job of old, by searching, trying to find out God. It is often lost sight of, that nature is just as true a revelation of the Deity as is the record of the Book of books; and the scientist, no less than the theologian, is a student of God and his laws. What we call natural laws are but our formulations of the method by which God has worked in nature. The study of astronomy is the study of his universe; the study of geology, the study of how he fashioned this planet; the study of evolution, but the study of God's methods of creating all living plants and animals. The time will come when religion will look back to Newton and Kepler, Dalton and Joule, Darwin and Wallace, as God's interpreters, no less truly than to Augustine and Chrysostom, Luther and Calvin, Butler and Edwards.

¹ Lecture delivered before the Polytechnic Society of Kentucky, May 26, 1890, by James Lewis Howe.

But there is another aim of the study of natural science which is to the vast majority of mankind far more practical. It consists of study for the purpose of utilizing the principles of science for the benefit of mankind. From one standpoint this aim is philanthropic, in that it seeks to use its discoveries for the comfort and convenience of mankind. This aim is hardly less worthy than that of the pursuit of science for the sake of finding truth; but in far too many instances the incentive is not any feeling of philanthropy, but merely the acquisition of personal financial gain. In the constant struggle for the "almighty dollar," Science proves herself a valuable aid, but it is only by her prostitution. In the spirit of pursuing science merely for the money it will enable one to make, the true aims of science are wholly lost sight of; and it seems often as if unhappily by far the greater number of the devotees of science are devotees merely for the money in it, like the money-changers whom Christ drove from the temple precincts. The temptation which is continually offered to leave the paths of pure science for the sake of following industrial paths is very great, and is in danger of wholly obscuring, or at least of allowing to fall into the background, the true aims of science. Of course, incidentally the human race is vastly benefited by the attainments of those who have no thought but of gain; nevertheless it cannot fail to lower science in the eyes of thinking men. Many great discoveries of the last few years have been very valuable for the world; but often, too, they have given rise to vast and grinding monopolies. It is almost alone in the sphere of medicine that the profession have kept their standard so high; and it is by them universally held that any great discovery is the property, not of its discoverer, but of all humanity. The true scientist would far rather be a Jackson or a Koller, and give to suffering mankind the wonderful alleviators of pain, ether and cocaine, than to amass millions through some patent monopoly.

Look for an instant at the vast multitude of patent-medicine advertisements which cover our fences and walls, and fill the columns especially of our religious papers. What are we to think of a man, who, if his claims be true, possesses a specific that will cure every case of consumption, or bright's disease, or some other ill of flesh with which the regular practitioner admits he is wholly unable to cope—what are we to think of such a man, when he will part with his discovery only in payment of an outrageous fee, and who will suffer hundreds and thousands to suffer and perish, in order that he may make a fortune? Is he one whit better than the physician who would allow a patient to die rather than treat him, when there was no hope of his bill being paid? The one

we call inhuman, into the coffers of the other we pour our millions. It seems to me we err when we consider any discovery of the truth whatsoever as the property of its discoverer. It is true that he who labors with the mind should receive a reward for his work, just as well as he who labors with his hand. But even our patent system does not acknowledge a man's property in his discovery: it merely gives him a monopoly of it for a few years, and then it comes into the possession of mankind, to whom it all the time belonged. There may be much fallacy mixed up with what truth there is in Edward Bellamy's "Looking Backward;" but there is no doubt but that the greed for gain is one of the darkest of the stains upon the escutcheon of our boasted nineteenth-century civilization.

Happily and naturally the great discoveries of the world have not proceeded from this avaricious spirit. As a rule, the aim has originally been solely to seek truth. It is only when the discovery has been made, that the temptation has proved too strong, and the worshipper has turned his back on the pure shrine of truth, and bowed his knee to the shrine of Mammon.

Having thus sketched briefly what appears to me the true aims of science, it is my purpose now to consider the rapid growth of science in the past, and from this, as far as it may be possible, to point out the as yet unconquered fields and the hints of what we may expect of science in the future. Down to the time of Aristotle, natural science can hardly be said to have had any existence. Here we find its dawning, when the method of deducing the law from the individual phenomena was first proposed by that far-seeing philosopher. It was, however, but the dawning, and the day was long in breaking. All through the later civilization of Rome, and through the dark ages, the advance was at a snail's pace. Alchemy recognized the true aim,—search for truth,—but to attain this aim resorted to such deception, that her lack of fidelity to the truth retarded the development of true science many centuries. Roger Bacon with prophetic vision foresaw the day that was soon to break, even as his more illustrious but infamous namesake of Verulam realized, as no other of his time, what that day would bring. Kepler, Galileo, and Newton caught the first glimpses of the rising sun, and from their time to ours the progress has been with ever accelerated velocity.

Of the four great generalizations of natural science thus far discovered, but one dates back of the present century,—that of universal gravitation. The importance of this discovery cannot be overestimated, inasmuch as this was the first time an attempt had been made to include universal phenomena under a single law. We, with our modern knowledge, are apt to underestimate the effect of thus introducing the new principle of universal generalization into science. True, Newton did not explain the cause of gravitation, nor can we. It remains for some future philosopher, some greater Newton, to show how matter can act on matter at a distance, if it does; to show us whence came that runaway star crossing the great starry disk of the universe at inconceivable speed, what force set it going, and whither it tends; to tell us why the tail of the comet is repelled by the sun, and not attracted, as all material bodies should be; to explain to us the relation existing between what we call matter and the so-called luminiferous ether. It seems to us to-day as if gravi-

tation were but a special instance of some greater, infinitely farther-reaching law, by which cohesion and chemical affinity, and a host of other phenomena to-day inexplicable, will all be made clear. Such a generalization the science of the future may hope to make.

With the opening of this century, science began to make rapid strides. The chemist of the last decades of the last century began to suspect the indestructibility of matter, and under Berzelius and Lavoisier quantitative analysis became well established. It seems strange to us to-day that such an idea as the annihilation and creation of matter could have ever been held: and yet when we think of the burning of a piece of wood or coal, with only a bit of ashes left, the other products of the combustion having vanished into thin air; when we think of the solution of a piece of iron or zinc in acid with the liquid apparently unchanged; when we think of the coating of copper formed on a knife-blade immersed in a solution of blue vitriol; when we think of how our fathers were taught that heat was a material substance which mysteriously entered into or left other substances under certain conditions,—our wonder becomes less. It remained for a Dalton to open this century with the second great generalization of science, the atomic theory of matter, which includes within itself the idea of the permanence of matter. To him all matter was made up of atoms, infinitesimal in size, unchangeable, and few in species; but by the union of the different kinds of atoms all the multiform substances which we know arise. It is true that we find the idea of the atomic constitution of matter more than hinted at in the old Greek philosophers, and some have sought to show that Democritus, and Empedocles were the real originators of the theory. But to these Greeks the atoms were but philosophic abstractions, perhaps we might better say clever guesses: to Dalton they were experimental facts. The investigations of later chemists have justified the views of Dalton, and yet have shown their incompleteness. Mendeljeff and Newlands and Victor Meyer have demonstrated the close dependence of the properties of any element on the weight of its atoms, thus enabling them to predict the properties of elements then unknown, but whose subsequent discovery has verified their predictions. Crookes has shown the probability that what we call elements in many cases may not be true elements, but mixtures of elements so closely similar that he calls them "meta" elements. Many chemists have hazarded the guess that all our elements are in reality not simple, but compounds of some one as yet undiscovered, absolutely simple element; and it remains for the chemist of the future to point out the true nature of the chemical atom.

After the time of Dalton, chemistry received an impetus greater than any it had heretofore received, by what we can characterize as the discovery of organic chemistry by Wöhler in 1828. Up to this time the existence of so called vital force had been almost universally believed in. Under the influence of this force arose all the phenomena which we call life, and which were thought to be wholly different from all other phenomena, and beyond the study of man. Substances which were formed by life it was supposed could be formed in no other way, inasmuch as life force was a force which must ever elude man's investigations. But quite by accident Wöhler formed the first organic substance from one with whose formation life had had nothing whatsoever to do. For

years the truth of his discovery was denied by philosophers; but the chemists pursued the even tenor of their ways, multiplying continually the number of organic substances artificially formed, until to-day the field of organic chemistry has manifold more investigators than that of its elder sister, inorganic chemistry. Thousands, we might say millions, of organic substances have been formed. The dye-stuffs turkey-red and indigo, as well as hundreds of the aniline dyes so called, the formation of which Dame Nature has never attempted, and many alkaloids, are chemistry's best reproductions of nature's work; and within a few months grape and fruit sugar have yielded up their secrets. Few will be the years, perhaps months, before even cane-sugar, and morphine and quinine, will be in the list of the chemist's triumphs. Indeed, there is hardly a substance which nature can form that the chemist despairs of reaching. And why not, when we consider that the same forces are at his disposal which Nature uses in her laboratory? Life is merely the director of these forces. Nevertheless we are not to consider, however great may be his attainments, that the chemist will ever form life itself. The living protoplasmic cell is something more than a complicated aggregation of complex molecules, that exists when life has left the cell; but not until we can make alive the protoplasm from which life has just departed can we hope to pass in our laboratories beyond the making of dead protoplasm.

Coming down to a date a little later than that of Wöhler, we meet the third great generalization,—that of the conservation of energy. Long after the idea of the permanence of matter had permeated science it was still believed that energy was controlled by no such law. The revolving wheel came to rest a moment after the force ceased to be applied; the rifle-bullet struck the wall, and its energy left it; the stone fell into the water, made a splash, and in a moment all was at rest (the energy in the stone had disappeared). It was only when it was realized that heat was merely a form of motion,—motion of the atom and molecule, and not of the mass,—that the conception became possible that energy, like matter, was imperishable. The wheel indeed stops, but its motion is lost by friction, and converted into heat: the molar energy has merely become molecular and atomic. The rifle-bullet has stopped, but it is hot, and the lost motion of the bullet is now making move more rapidly, and through longer paths, the molecules and atoms of the lead. The stone has fallen, but the water into which it fell has been warmed by that transference of energy; and it was Joule who showed that the heat which the water has received can be converted back into molar motion, and is just sufficient to raise the stone to the height from which it fell. Thus, while energy appears in protean forms, it is never lost; and this law we find to be no less true in the inorganic world than in the world of life. The work we do, and the heat of our bodies, are the exact equivalents of the combustion of the food we eat, with the oxygen of the air we breathe. This law has, since its discovery, formed a criterion in the judgment of the efficiency of all kinds of machinery, enabling the determination of the proportion of the energy applied as fuel or otherwise, which is utilized; and thus it further enables the saving of great amounts of energy by showing where the loss lies.

The acceptance of the fourth and last of the great gener-

alizations of science is within the memory of most of my audience. I refer, of course, to the idea of evolution. That there had been a progressive development of species of plants and animals from their first appearance on the earth, was long ago believed. It was taught in the Arabian schools during the dark ages of Europe: we even find it hinted at in the apocryphal books of the Old Testament. Lamarck tried to explain it, and Darwin's illustrious grandfather seemed imbued with the theory. Goethe was on the verge of its discovery. But it remained for Charles Darwin to so present the evidence and to explain the plausibility of its truth, that the world of science should come to believe that evolution is a fact. More, perhaps, than any of the three earlier great generalizations of which I have spoken, was that of evolution far-reaching in its influence. In little more than a quarter of a century we have seen the idea of evolution permeate the fields of history, philosophy, law, politics, philology, and even theology. It matters not in our present consideration whether or no it be a fact that man was developed from a lower form of life, whether or no life originated spontaneously from inorganic matter. These are points to be settled by evidence; and as to the evidence, scientists differ. These are but very special and minor applications of the generalization. The great idea which evolution emphasizes is that Nature does not move *per saltum*, but is uniform in her working; that God works according to what we call laws, and not arbitrarily, and that he will not suffer his highest creation, man, to be put to permanent intellectual confusion. In the application of evolution, Darwin sought to show how it was probable the development of organic nature was brought about. This does not affect the question of development of itself, which is a question of fact, to be accepted or rejected according to evidence. It has been accepted by the vast majority of all scientists; but the present work of biologists is to philosophize, as did Darwin, as to the why of evolution. He presented as chief cause the survival of the fittest in the struggle for existence; he later added sexual selection as a powerful factor; and other naturalists have proposed many other causes, more or less far-reaching in their influence.

Thus the study of evolution in the organic world to-day is a philosophy of evolution; and we may say that thus far there is comparatively little agreement among the philosophers. It remains as a great problem of the future, the solution of which perhaps none of us will see.

It is perhaps more to evolution than to any of the other great generalizations that the great progress science has made in the last quarter of a century is due; not, indeed, to its direct influence, but rather to the stimulus and impetus it has given. It perhaps might be said with truth that science has made more progress during each decade of the present century than it had made in all time previous to the opening of that decade. This is particularly true of the last ten years. While the advance here has been most largely in the realm of applied science, yet one discovery in the field of pure science ought not to be omitted, which may yet prove to be more far-reaching than we yet anticipate. I refer to the demonstration by Herz, that electricity, like heat and light, is a form of vibratory motion of what we call the luminiferous ether. To be sure, for many years it has been foreseen that this must be the case; but yet, when the dem-

onstration really comes, we are hardly prepared for the vast change in our ideas it occasions. We have been used, for the most part, to study electricity in conductors; but it now appears that this is but a special case, that we really must study electricity in the space around the conductors. Some go so far as to say that in the not distant future we shall have no more use for the words "heat" and "light," but our text-books on physics will treat in their place solely of electricity.

There is one other field of pure science to which I would like to refer this evening,—that of astronomy. When the Dutch scholar held two lenses together and saw distant objects brought near, he little thought of the revelations which would be made by the telescope of the future; he little thought of seeing the moon as if it were but ten short miles away, of viewing millions of stars where the eye sees none to shine; he little thought of seeing two miniature worlds revolving around the planet Mars,—worlds so small that we could pack several of them away in one of our Kentucky counties. It is, however, when we lend to our telescopes the aid of photography and the spectroscope that our knowledge of the universe outside of us becomes so almost infinitely enlarged.

From the spectroscope we have learned that the sun is composed of the same elements we know on our earth, that even the most distant star is but a sun like that of our solar system, that the comet is perhaps but a stream of meteors like those which our earth is continually meeting in its journey through space, that the material of all the universe is one. We learn more: for we see the genesis of worlds: nebulae condensing to suns, and suns cooling to a state like our own luminary; and yet, further, we are, as it were, in the very presence of the creation and of the death of stars,—stages our system has millions of years since passed through, and those through which it will pass centuries after we are gone.

So, too, when we find upon the photographic plate the print of stars so far away that we cannot see them even in our most powerful telescopes,—stars from which the light-vibrations which have left their impress on the plate may have started long before the first man appeared on this earth,—we feel ourselves almost in the presence of infinity itself. Is there no end to the universe, no point beyond which there do not stretch worlds on worlds? Will the science of the future answer this? Who can tell?

Turning now from the, to my audience, perhaps less familiar field of pure science, to that which cannot fail to force itself upon the attention of every one, the applications of science, we find that probably the most important single discovery is that of the steam-engine. Who could have dreamed, when that little boy sat watching the cloud of steam from his mother's tea-kettle, of the millions of applications the world was to see in the next century? Who could have imagined, when he allowed his imagination its wildest flights, that through this power civilization itself would have been revolutionized?

Agas ago the energy of the sun was stored up in the vast coal-beds of every quarter of the globe. Until the discovery of the steam-engine, man had left all this source of energy untouched. To-day he is just beginning to realize the immense capacity for work presented to him; and

yet how wasteful he is! It is for the scientist of the future to present a way that this energy can be fully utilized, since to-day, without thought for his descendants, man is scattering by far the greater portion of this energy to the air. A steam-engine which will return more than a few per cent of the possible energy of the coal is yet to be devised. Nevertheless, imperfect as the best steam-engine is, think of the improvement on the time of our grandparents! The annihilation of time and space has begun. We rush along the iron rail at a mile a minute quite as a matter of course, and a Boynton has promised us a trip from New York to San Francisco in a day; a week or less carries us across the Atlantic, and a George Francis Train needs but the time of a school-teacher's vacation to girdle the globe. Our latest journal brings us news that Jules Verne's "Twenty Thousand Leagues under the Sea" is no longer a fancy, but that the successful submarine boat has become a fact. Still More's Utopia has not yet been fully reached. The air remains as an unconquered field; but who can doubt that the time will come, and that perhaps in the not far distant future, when man will vie with the eagle in his flight, and thus friction, the great impediment to rapid transit, will be reduced to a minimum? "The birds can fly, and why can't I?" is not merely the foolish quandary of Darius Green: it is the sober inquiry of many engineers.

The advance in the field of applied chemistry is not behind that of engineering. Most striking is the cheap production of steel. From the days of the Kabyles, little advance had been made down to a comparatively recent date; but the invention of what is commonly known as Bessemer steel,—an invention, by the way, of one of our own citizens,—has opened the way to the replacing of iron by steel for a multitude of purposes, and presages the day when steel will almost completely take the place of iron. And yet prophets tell us that not steel, but aluminum, is the metal of the future. The price of this metal is continually being lowered, never more than within the past year or two; and it is certainly capable of many applications. It may be that even steel will not be able to hold its own, though I confess such is hardly my judgment.

In the field of applied chemistry is one of the best illustrations of the fact that if man can clearly state a problem, he can solve it. Napoleon offered a large reward if any one would devise a simple method of manufacturing soda from salt; and among the processes presented was one which is to-day still in use, practically unchanged in principle from Le Blanc's specifications.

With the developments of the soda industry has gone hand in hand that of soap-making. It is hard for us to believe that there could have existed a civilized people who did not use soap; but we are told the Greeks had no soap, and that the Romans used it only as a cosmetic. Still it is none the less true that, as has been said by another, it is possible to judge the standard of civilization of a nation by the amount of soap which it uses. Perhaps the two other most striking and most promising developments of applied chemistry are those of the synthetical formation of dye-stuffs and drugs.

Many of you doubtless remember the furor occasioned when the first aniline dyes were thrown on the market, and the fortunes made and lost. Yet who could have foreseen the

almost infinite number of colors which we may to-day see, especially among the silks, in a dry-goods house? The color-sense of the modern European and American has developed in a wonderful degree in the last quarter of a century; and can we doubt that "rods and cones" have either undergone a remarkable increase in number, or else have been marvelously educated? The most striking of the advances in this line was the artificial formation of alizarine, the dye-stuff known as turkey-red, and which, preserved to us still unfaded as Egyptian mummy wrappings, justifies the biblical comparison of sin to "scarlet." Indigo has been in more than one way synthetically formed; and it is certain, that, even as the alizarine manufacture has completely ended the cultivation of the madder, so it will be but a few years before the chemist will vie with nature in the manufacture of indigo. But it would seem that the industrial chemist does nothing half way. Not satisfied with imitating nature, the dye-stuff chemist has for his aim the production of colors of any wave-length or any combination of wave-lengths whatsoever, and he seems not to waver in his course toward this goal.

Salicylic acid, salol, antifebrin, sulphonal, and homatropin stand among the brilliant examples of what chemistry has done for the medical profession; but we shall look in the near future to the artificial formation of quinine and morphine, and any other drug that may be demanded. Perhaps here the field of physiological chemistry will in the future hold sway, and we may live to see the time when the drug will be manufactured directly for the purpose of meeting certain symptoms. This looks by no means impossible, in view of the recent introduction of a large and ever-increasing number of antiseptics, antipyretics, and hypnotics. When it has once been determined what is the relation existing between chemical composition and physiological effect,—and this is to-day the field in which physiological chemistry has the most to hope,—then will the time have come when not only medicine will have been rescued from the bonds of empiricism and reduced to a science, but chemistry will be acknowledged as her handmaiden, furnishing the physician that special drug which will play the specific in each individual case.

This leads us to the field of medicine and surgery. Of course, the most marked advance in this department is the general acknowledgment of the germ theory of disease. It may be that in the majority of cases the peculiar germ of the disease has eluded discovery, it may be that the germ theory is but one side of the subject of origin of disease; nevertheless it is true that medicine and surgery, under the influence of this theory, are undergoing a marvellous change, which is destined to add months and years to the average life of man. Jenner walking in the darkness, and Pasteur in the twilight of early dawn, have traced the path which our successors decades hence will follow. We must not marvel if, in the dimness of early morning vision, all is not as clear to them as it will be generations hence, but rather wonder that in the faintness of the light they could have caught the first glimpses of the coming day.

We to-day can see clearly that the task of the physician of the future will be not so much to heal disease as to prevent it; and may we not look forward to the time when every germ of consumption and scarlet fever and diphtheria,

and other kindred diseases, will have been exterminated, even as the Diornis of New Zealand and the buffalo on Western prairies? This being the case, surgery will be robbed of its terrors, and its advances in the past decades will be as nothing to what the future has in store.

If I were asked to name the subject most attracting the scientific man of to-day, I should answer electricity; if I were asked to name the field in which there is the greatest opening for a scientist, I should say electricity. When looking at this field, we are looking at a field which is hardly yet in the earliest stages of infancy. To be sure, the application of electricity to the telegraph and telephone seems to us an old story; but the developments which must follow the recent discovery of Herz of the true nature of electricity will undoubtedly bear fruit in the improvement of these instruments. When we further take into consideration the subjects of electric lighting, electric motors, and electric welding, we have every thing to hope for the future. Indeed, now that we may consider the study of electricity founded upon a solid basis, the wonders which a few decades will bring forth cannot be foretold.

And now, were I asked to suggest the great problem which is to tax the ingenuity of the scientist of the future, I should say it would be the utilization of energy. To-day we have practically going to waste the energy of the sun and wind, and wave and tide, and even that of our great cataracts. We could hardly compute the infinitesimal proportion which is utilized by the various wind-mills and tide-mills, and turbines beneath Niagara. The stored energy of the sun in the carboniferous period still mostly remains unused by us in our coal-beds, but these will eventually be exhausted. Nevertheless the sun is to-day furnishing us just as much energy as then, and it only remains for the future scientist to devise some method for its utilization; and we cannot doubt this will be done. Again, the scientist of the future will devise some method by which the energy of fuel will be converted into electricity without passing through the stages of the steam-engine and dynamo, in which by far the largest portion is lost. The energy of the combustion of zinc is converted with little loss into electricity. Who will be the man to invent a battery in which the energy of the union of carbon with oxygen will be directly converted into electricity? When, still further, we to-day take the energy of coal and convert it into steam, thence into engine motion, thence into electricity, thence through the incandescence of carbon into electric light, we do it at tremendous loss. The glow-worm and the lantern-fly effect the same transformation with scarcely a trace of heat, and, as far as we know, with little loss. One of the greatest problems of the future will be the transformation of carbon energy into light in some similar way, when a single pound of combustible material will furnish us as much light as is now obtained through illuminating-gas or the electric light from a ton of coal.

And what now shall we conclude of the future? Will the time come when by improved machinery one man's labor will clothe and feed a hundred? Will our bread and meat be made for us by the chemist from coal and water and air? Shall we traverse the earth and air and water on the wings of the lightning? Will the vagaries of Edward Bellamy become facts, and money vanish, and with it avarice

and all its accompanying vices? Will the poet's dream come true?—

“Men, my brothers, men the workers, ever reaping something new:

That which they have done but earnest of the things that they shall do:

“For I dipt into the future, far as human eye could see,
Saw the Vision of the world, and all the wonders that would be;

“Saw the heavens fill with commerce, argosies of magic sails,
Pilots of the purple twilight dropping down with costly bales;

“Heard the heavens fill with shouting; and there rained a ghastly dew

From the nations' airy navies grappling in the eternal blue;

“Far along the world-wide whisper of the south wind rushing warm,

With the standards of the peoples plunging through the thunder-storm;

“Till the war-drum throbbed no longer, and the battle-flags were furled

In the parliament of man, the federation of the world.

“There the common sense of most shall hold a fretful realm in awe,

And the kindly earth shall slumber, lapt in universal law.”

Whether these things will be realized we know not. In view of the past, we dare not say our wildest dreams and fancies will not to-morrow be realities. But this we know: that wherever it is possible to benefit mankind, to alleviate suffering, to elevate humanity, and to raise man more nearly to the true image of his Maker, there the aid of natural science will never be found wanting.

THE SECOR SYSTEM OF MARINE PROPULSION.

FOR over four years there has been in process of development in the city of Brooklyn a system of propelling vessels which it is believed will offer distinct advantages over the marine steam-engine. The following is a brief description, condensed from “General Information Series,” No. VIII., of the United States Navy Department, for 1889:—

“The propulsion of vessels by the liberation of a large volume of gas by explosion and the displacement of water thereby has been tried, and has met with some success.

“The method employed is the invention of Mr. Secor, and is fitted to a vessel 100 feet in length, called the ‘Eureka.’

“The apparatus consists of two horizontal tubes about twenty inches in diameter, placed fore and aft in the after part of the vessel below the water-line, the after ends being in communication with the sea. Petroleum in the form of spray, and air under pressure, are injected into the tubes at the forward ends, and exploded by electricity. The disengaged gas expels the water from the tubes, and the re-action against the forward ends of the tubes propels the vessel. The explosions are arranged to take place alternately in the cylinders, and the firing mechanism to work automatically. Sixty explosions a minute in each cylinder have already been obtained, giving quite a uniform motion.”

In 1824 Sadi Carnot propounded the great principle that the useful effect of any heat-engine was independent of the nature of the working fluid, and depended solely on the extremes of temperature in the working cylinder; or, as it has been expressed, it depends on the range of temperature of the working fluid during its working cycle. Sir William Thomson determined the exact expression for this efficiency, and it was also deduced analytically by Rankine as follows:—

$$E = \frac{T' - T^2}{T'}$$

T' is the temperature above the absolute zero at which heat is supplied; and T^2 , that at which it is rejected.

In the “Encyclopædia Britannica” (edition of 1889), article “Steam-Engine,” Professor I. A. Ewing points out that in the cylinder of a gas engine the efficiency would be 87 per cent, if it were possible to expand down to atmospheric temperature and dispense with a water-jacket: thus in Centigrade temperature,

$$\frac{2173^\circ - 288^\circ}{2172^\circ} = .87 \text{ nearly.}$$

This would represent an efficiency six times greater than the most economical triple expansion steam-engine.

The conditions which are impossible in any cylinder containing a moving piston are obtainable by the Secor thermo-dynamic method. The necessity for the wasteful water jacket at once disappears. The degree of expansion with its concomitant fall of temperature is only limited by the temperature of the sea, which constitutes the thermo-dynamic cold body or refrigerator. It may be remarked that the discharged gases, consisting principally of air, nitrogen, and carbonic acid, are poor radiators of heat, thus limiting antecedent heat-waste.

The conditions of the Secor cycle are, then, an explosion or combustion at the highest temperature—the dissociation limit—within a heated chamber, from which the outflow of heat may be prevented by suitable linings, the non-radiating products of combustion expanding in re-action against the coldest medium provided by nature (the ocean); the cooling being coincident with, and not antecedent to, the mechanical effect.

Science is to-day making demands of the steam-engine which it can never satisfy. Science says, let no heat escape from smoke-stack, or radiate from boiler, steam-pipe, or cylinder; then increase the range of temperature four or five fold that of the quadruple-expansion steam-engine. Hitherto the reply of the engineer has been, that, inasmuch as no conversion of energy can occur without some loss, even 85 or 90 per cent is, after all, not too great a tribute to pay to nature.

Thurston shows that the cannon does much better, yielding nearly 50 per cent of thermo-dynamic efficiency. The electrician working in a new field, undeterred by precedent, guided only by a knowledge of the laws which relate to the conservation and correlation of energy, has accomplished still greater results. An efficiency of 90 per cent in the dynamo is one of the grandest achievements of applied science.

Although the method of propulsion in the Secor system involves a radical change as compared with the screw, it is not impossible to estimate the efficiency of an air-jet under the circumstances indicated. The limited area of a jet of air or water has been supposed to involve a great loss of efficiency. This idea has arisen principally from erroneous conceptions in respect to the screw.

It was at one time an axiom in engineering, that the larger the exposed area of the screw, the more effective would be its action. Experience has shown the fallacy of this idea. Data of the trials of three large transatlantic steamers, showing the comparative merits of large and small screws under similar conditions, are given by Arthur I. Maginnis, Esq., in a paper read before the Institution of Naval Architects. He remarks, that “by these results it will be seen that propellers of small diameter have in each case proved the most economical and effective, both increasing the speed and decreasing coal-consumption.” Mr. Isherwood has shown that decreasing the number of blades in a screw causes no falling-off in speed. Mr. Ericsson's theory was directly opposite in the early days of screw navigation. It was considered a peculiar advantage in the Ericsson screw that it had six blades. Mr. Griffiths has proved that increasing the hub area up to one-fourth the total diameter does not lessen the speed. Speaking of the tip of the blade, Mr. Barnaby says, “The tip of the blade is very little good, only you must have a tip.” The exposed area need be only sufficient to absorb the engine's power: more than this is a loss.

Not only were the early engineers mistaken in regard to area, they were equally erroneous in the theory of slip. Mr. W. Froude remarks, “that to assert that a screw works with unusually little slip is to give proof that it works with a large waste of power.” He remarks further, “Experiments which have been in progress since this paper has been in type show conclusively that the decrease of efficiency consequent on increasing slip, with screws of ordinary proportion, is scarcely perceptible.”